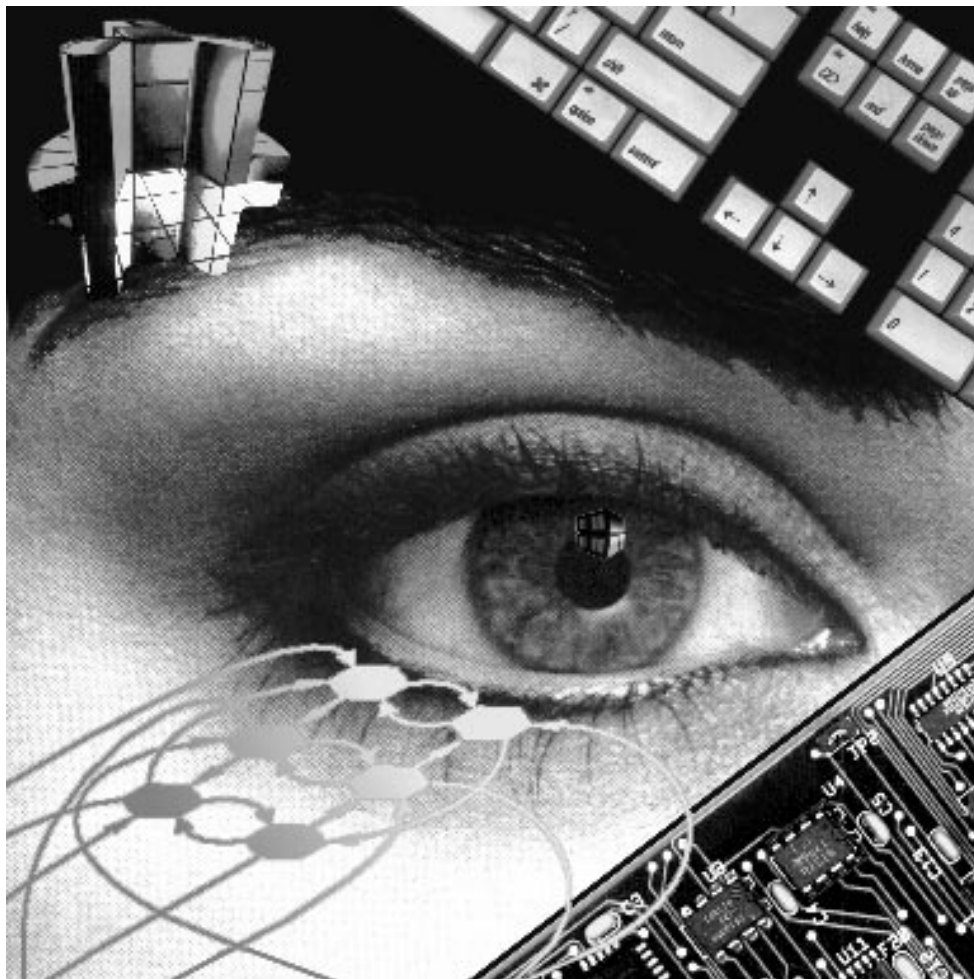


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# MODEL NETS

*A National Study of Computer  
Networking in K-12 Education*

Sponsored by the U.S. Department of Energy



**Los Alamos**  
NATIONAL LABORATORY

**Model Nets**  
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# Model Nets: A National Study of Computer Networking in K–12 Education

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## **The Model Nets Study**

Model Nets was a national study of the characteristics of computer networks that positively impact teaching and learning in grades kindergarten through 12 (K–12). Conducted by Los Alamos National Laboratory and funded by the Department of Energy, the study defined “positive impact” as the use of a network to support a discovery-based and student-centered model of learning in which students explore, discover, create, propose explanations and solutions, and take action on what they have learned. This model influenced the study design and methodology.

## ***Meeting the Need***

The Model Nets study originated to address the needs of a consortium of federal agencies responsible for funding networking projects. The agencies included the Department of Energy, Department of Education, National Science Foundation, Department of Commerce, Department of Agriculture, National Aeronautics and Space Administration, Advanced Research Projects Agency, and National Institutes of Health. Responding to a national mandate to network all schools, the consortium wanted criteria it could use to select the best and most appropriate projects. It also wanted information about successful “scale-up” and expansion of existing network environments.

## ***Characteristics of Effective Nets***

Model Nets was devised to be sufficiently wide in scope to allow for the development and support of recommendations about how federal agencies can make the most effective use of taxpayers’ dollars in funding networking technology projects in K–12 schools. We designed the study to identify and describe those characteristics that either enhance computer networking or create obstacles to implementing effective networks in schools. Using the data collected during the study, we developed a set of guidelines for implementing effective computer networks. These guidelines can help federal agencies in making funding decisions related to networking technology projects in K–12 schools. The guidelines also will be useful to school districts as they plan and implement computer networks.

## **Design of the Study**

Keeping in mind several factors based on the needs of federal agencies and of school districts, we set out to design a study that would

- incorporate previous research about effective use of computer networking in school districts;
- draw upon the computer networking knowledge of a team of experts in network technology and education;

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- incorporate site visits comprising interviews, focus groups, observations, and document reviews to examine a large, diverse set of districts across the country using computer networks; and
  - conduct a survey of all teachers at the districts in the study to determine their use of computer networks and to complement the findings of the site visits.

### Research Questions

Thirty-four research questions guided us in creating the data collection instruments for the site visits and the teacher survey, in conducting site visits, and in analyzing the data. The questions can be summarized as follows:

- Did the sophistication of the network infrastructure (as measured by its bandwidth; topology; connectivity; capabilities or functions; number, type, and location of networked stations; and performance) appear to have any bearing on the extent of use, impact, and/or integration of the technology?
- Did the development of any particular policies or procedures (related to vision, planning, resource distribution, funding, community involvement, evaluation, leadership, access, or use) appear to have any bearing on the extent of use, impact, and/or integration of the technology?
- Did any particular teaching and learning practices (related to instruction, assessment, administration, professional development, or design of learning environments) appear to have any bearing on the extent of use, impact, and/or integration of the technology?

### *Phases of Design*

We conducted the study in three phases:

- **Phase I: Planning the Study.** This phase included reviewing literature and previous research, forming a project planning team, developing data-collection instruments, and piloting the instruments and approach to site visits.
- **Phase II: Collecting the Data.** This phase included assembling and training 10 site visit teams, conducting three-day site visits to school districts across the country, and conducting a survey of teachers at those districts.
- **Phase III: Synthesizing, Analyzing, and Reporting the Data.** This phase included distilling effective practices from site observations and survey responses, writing the report, and creating the guidelines to effective practice.

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***Technical  
Infrastructure,  
Policy, and Teaching  
and Learning***

Our methodology was to gather (1) descriptive data from the observational site visits and (2) complementary survey data. This approach provided us with qualitative and quantitative data from a number of perspectives about characteristics of computer network use in school districts. We synthesized these data within the three domains that framed our study: *technical infrastructure*, *policy*, and *teaching and learning*. Based on this synthesis, on the collective knowledge and judgment of our experts, and on the findings of previous research, we compiled the characteristics of effective practice into guidelines. We also developed a list of the barriers that inhibit effective networking.

We centered the observational aspect of our field study on site visits to a national sample of public school districts making widespread use of computer-based networks, as determined by the 10 regional education laboratories (RELs) of the Department of Education. We focused on districts as our unit of analysis for two reasons: (1) we sought to understand the impact of wide area networks (WANs), a technology that transcends individual school use and is best suited to multiple, physically separated sites, and (2) decisions about policy and funding are generally made at the district level.

***32 Districts  
Nationwide***

In the 10 REL regions, we selected a sample of sites representing a range of economics, geography, and demography. Model Nets research teams conducted visits to 32 districts and a sample of 93 schools within these districts. It should be noted that as the site visits proceeded, we saw considerable variation among districts in their degree of network implementation. This gave us an ideal opportunity to learn more about how schools overcome inherent barriers and constraints in expanding the use of their networks.

***Site Visits and  
Teacher Surveys***

During each site visit, the site visit teams interviewed staff, conducted focus groups, observed education practice and facilities, and reviewed existing documentation. They collected data from teachers, students, technology coordinators, administrators, and community members. The teams also collected previously distributed written surveys of teachers at each of the schools they visited. Finally, the teams wrote descriptive case studies of the sites, describing each site in the framework of the three domains: networking technology infrastructure, policy issues, and teaching and learning practices using the network.

Teacher survey questions focused on the impact of computer networks on the teaching and learning domain. The surveys did not address policy or technical infrastructure, two domains in which administrators and technology coordinators were better sources of information. We distributed surveys to teachers at 93 schools in the 32 districts of the Model Nets study. We received surveys from 1,374 teachers at 60 schools in 26 districts, which represented approximately three-fourths of the districts and two-thirds of the schools in the study. Respondents comprised 45% of

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the teachers in the schools where surveys were completed, and they represented 31% of all teachers in all the schools visited.

## Principal Partners

Throughout the study, Los Alamos engaged in major partnerships with the University of California–Los Angeles Center for the Study of Evaluation (UCLA), the U.S. Department of Education through its RELs, and Boyer & Associates.

- UCLA assisted in the design of the study, administered the teacher survey and analyzed the survey data, and participated in Phase III.
- The collaboration with the RELs represented one of the first major initiatives between the Department of Energy and the Department of Education under a newly signed memorandum of understanding by the Secretaries of both agencies. The RELs drew upon their relationships with state departments of education, school districts, colleges of education, and other groups in their regions to select sites and site visit teams for their regions. Representatives from the RELs also participated in the data analysis activities of Phase III.
- Boyer & Associates facilitated the training for the site visit teams, assisted with supervision of the data collection, and participated in Phase III.

## Next Steps

We are developing a handbook and multimedia-based guide to translate our findings and recommendations into a user-friendly format to help schools set up their own computer networks. Our plans include distributing information on the World Wide Web, disseminating the guide to schools and districts, and distributing our data collection instruments so that other agencies and school districts can explore or evaluate network use in school districts.

## About the Report

The Model Nets report is available in its entirety from

Los Alamos National Laboratory  
Science Education and Outreach  
MS P278  
Los Alamos, NM 87545

The full report comprises the following chapters:

- **Introduction:** Describes the rationale for conducting the study and includes a brief discussion of design, partnering, and next steps.
- **Background of Study:** Summarizes the findings of previous, related studies and literature that helped refine the research questions which formed the foundation for the Model Nets study.

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- **Design and Methodology:** Describes the methods of the study, including the formation and training of site visit teams, the development of data collection instruments for the site visits and the teacher survey, and the procedures for gathering and analyzing the data.
  - **Descriptive Findings:** Reports a synthesis of the data gathered through site visits and an analysis of the teacher survey; discusses obstacles to effective computer networking.
  - **Guidelines for Implementing Effective Computer Networks:** Outlines the characteristics of effective practice for using computer networks in school districts, where “effective practices” are defined as those that support discovery-based, student-centered learning.
  - **Conclusions and Recommendations:** Interprets the significance of key findings, suggests additional avenues for research into computer networks, and presents several recommendations for funding agencies and school districts.

## Descriptive Findings

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We report several key findings in each domain of the study. They are referred to as key findings because in some cases they provided solid reinforcement for commonly held truths about computer networking in schools or they defied our expectations. In other cases, we felt a finding was key because it emerged as a prominent feature of network use across most sites. Most of these key findings are represented in the guidelines as characteristics of effective practice.

### Technical Infrastructure

From the site visits, we found that most districts had originally approached networking for one of two reasons: to support administration or to enhance teaching and learning. Thus, the networks were either partitioned between the two realms or physically separate (that is, two networks, one for each purpose). We found that slightly more than half the sites had networks with completely separated administrative and instructional functions. Two networks were only focused on instruction, and 12 were used for both instructional and administrative purposes. Additionally, we found that most sites did not perceive network security or problems with security to be a major concern.

We found that while a majority of the sites had building LANs connected to district WANs, a third of them did not have such connections. Many of the districts that we visited were still setting up their networks, yet all but one district had access to the Internet.

Most of the networks were hybrids of various modes of transmission. Bandwidth tended to vary within sites, where different components of the infrastructure had different capabilities. Twenty sites (62%) had a maximum bandwidth of

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56 Kbps, which is marginal if a network is to carry video and voice data in addition to text and graphical data. Four sites had networks running at less than 56 Kbps, while eight sites had networks running at more than 56 Kbps.

## **Policy**

Key policy findings related to vision, leadership and decision making, access, planning, funding, and policy type. We found that many district visions for computer networking combined increasing administrative efficiency with supporting educational reform or else favored one or the other. In the area of leadership, we found that many districts reported that having a champion to spearhead networking efforts was a critical feature of successful implementation. We also found that decision making was most effective when it was shared between the district and the school site, whereas site-based management created obstacles to successful networking. And a clear majority of teachers felt that they had administrative support for computer networking.

We found that districts developing computer networks frequently were supported by state policies, particularly by state reform acts and funding formulas that favored networking. On the other hand, federal policy had less impact on districts. Many sites reported that they were wary of federal policy and entitlement programs, which they reported perceiving as unstable and potentially short-lived. In their own role as policy makers, many districts had established acceptable-use policies that defined appropriate and inappropriate activities on the network. In a related area, most districts were committed to ensuring wide and convenient access to the network for staff and students.

While our site visit teams found that most districts had a computer network plan, the teacher survey results indicated that a large number of teachers believed their districts lacked a plan. This discrepancy may hint at confusion over the planning process or at a lack of communication about the planning process at the district level. However, most districts did not have an evaluation plan to monitor the effectiveness of their networks. To fund its network, every district in the study relied on at least two—and often more—sources of financial support. Many districts showed an entrepreneurial bent in developing creative ways to either fund the network or to obtain equipment and software without expenditures.

## **Teaching and Learning**

As we looked at the use of computer networks in support of teaching and learning, one finding emerged consistently from a variety of teacher survey questions: computer networks are a force in elementary schools more than in middle schools, and in middle schools more than in high schools. This was true for impact on students, on teachers, on classroom practices, and on schools overall.

We found that the most common teacher uses of computer networks were to access information and resources and to perform



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administrative tasks. Teachers were receiving professional development in how to use networks, but not in how to best use the technology for instruction. And while all teachers had access to the network, not all students did; however, about one-fifth of the teachers surveyed had *never used* a computer network.

Most student use of computer networks was to access information, either locally or on the Internet. By using networks, students developed skills in accessing and locating information and in communications. Our data also showed that students and consultants were equally effective in providing training to teachers on using the network. The most effective method of training was by district and school technology coordinators and by teachers' peers.

We also found that use of computer networks helped to increase the presence of community members in school affairs.

## Conclusions

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Overall, our findings confirmed our high expectations for the group of districts selected for the study, which we had chosen for their pervasive use of networks. Our reflections on these findings included the following:

- The districts have impressive technical infrastructures that support a wide variety of services.
- The districts are exploiting these new resources. Almost all have direct access to the Internet.
- The districts have used networking to bring community members and other “outsiders” into the schools electronically.
- Districts use networks to increase administrative efficiency and to make district operations flow more smoothly through distribution of administrative data.
- Students, teachers, administrators, and other school staff are accessing information, using e-mail, publishing World Wide Web home pages, and otherwise communicating with colleagues, students, their communities, and others beyond their school. This network-facilitated communication is local, national, and international.
- Networks appear to spark motivation among teachers and students.
- As a learning tool, networks appear to be a vast electronic library and e-mail system that provides access to information and to other people not otherwise available.

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- Districts in general have not evaluated the impact of computer networks on student learning or achievement.
  - Few teachers receive professional development in how to plan curriculum that incorporates student use of computer networks as an integral part of student learning in alignment with district educational goals and objectives.
  - Local needs have not been studied and explicitly identified as part of the planning process for computer networks.
  - Schools use networks for teaching and learning in the most obvious or pedestrian ways, with scant attention being paid to their effectiveness.
  - Educational goals have not shaped the planning and implementation of networks.
  - Computer networks are not yet integral to teaching in these districts.
  - In most cases, districts appear to be constrained not by hardware or software, but by their teachers' knowledge of how to get the most out of them. The pedagogical uses of the networks do not reflect the sophistication of the infrastructure.
  - Classroom applications of networks are much the same across all districts, whether they have state-of-the-art networks with full-motion, real-time video transmission capability or borderline obsolete networks without even Microsoft Windows capability.
  - Network scale-up may best be accomplished by first getting all teachers on-line and by increasing their skills. Investing in their training—both in hardware and software use and in how to use the network to improve their teaching—will allow them to fully exploit network resources and capabilities.

### **Critical Questions Remain**

Thus, we are left with a few critical questions that demand further research:

- Do computer networks improve student achievement?
- If so, how do they improve it?
- Do computer networks foster improvements in teaching?
- Again, if so, how do they foster these improvements?

Answering these questions will help schools decide how best to use their limited resources to make the most of computer networks. Given the levels of funding and human energy currently pouring

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into the implementation of computer networks in schools, these questions warrant conclusive responses based on sound research.

## **Recommendations**

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Based on what we have learned from the Model Nets study, we have developed recommendations for additional research and recommendations to state and federal agencies that support computer networking in schools. The recommendations are listed below by category.

### **Recommendations for Further Research**

Additional research is required to deepen the understanding of networking in schools. That research should include

- investigating the effect of networking on student achievement and
- conducting a longitudinal study of computer networks in schools by revisiting in 3-5 years a sample of the districts studied under Model Nets.

### **Recommendations to Funding and Policy-Making Agencies**

Federal and state funding agencies should support school-district computer networking projects by providing long-term, stable funding for

- computer network projects that support local, district, and state education goals;
- school district networks that are widely accessible and used by students, teachers, parents, school staff, and community members at large;
- professional development for district and school staff;
- participation of technical experts to plan, design, implement, and maintain computer networks;
- implementation of districtwide WANs and school LANs with voice, video, and data capability; and
- high school networking projects for those districts that provide articulation of networking throughout grades K–12.

## **Guidelines for Implementing Effective Computer Networks**

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On the following pages, guidelines for implementing effective computer networks are offered as aids to federal agencies as they develop criteria for awarding funds to school districts implementing

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networks. The guidelines are also intended to help school districts to plan and implement computer networks. The Model Nets researchers derived these guidelines, or characteristics of effective computer networking, based on case studies of school districts, on teacher surveys, and on the expertise of a group of subject-matter specialists who reviewed the research results.

For the purposes of the guidelines, “effective practices” are defined as those characteristics of computer network implementation that support a model of learning in which students explore, discover, create, propose explanations and solutions, and take action on what they have learned. The guidelines are not intended as an all-inclusive or rigid set of requirements. Even an exemplary school district might not demonstrate every effective practice in the guidelines. Furthermore, many districts that were not included in the Model Nets research have developed other effective practices not mentioned here.

The effective practices are organized under the three domains of the Model Nets study: technical infrastructure, policy, and teaching and learning.

## **Technical Infrastructure Characteristics and Practices**

### ***Infrastructure***

1. The district provides convenient access to all users.
2. In a given school building, a single LAN supports video, voice, and data for both instructional use in all classrooms and administrative use.
3. In a given district, a single districtwide WAN supports video, voice, and data for both instructional and administrative uses.
4. The district WAN has multiple connections to the Internet.
5. The district provides users with dial-up access from home through external Internet service providers.

### ***Security***

1. Configuration-control software prevents users from “hacking” individual computers and thus rendering them incompatible with the network.
2. Proxy servers and firewall technology limit access to sensitive information, as appropriate.

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**Services**

1. All students, teachers, staff, and administrators have e-mail and share a common, districtwide e-mail system, which may include bridges between subsystems.
2. A shared, standardized network infrastructure serves all facets of education, including administrative and teaching functions.
3. The network supports a wide range of functions, including e-mail, file sharing, printer sharing, conferencing, access to productivity software (e.g., databases of student information), news groups, terminal connections, access to library databases and CD-ROM databases, access to the Internet and World Wide Web, security and climate-control systems, etc. (See Appendix E, Network Services.)

**Support**

1. A key server system provides centralized software distribution and configuration management.
2. Use of configuration control software (At Ease, FoolProof, etc.) helps support staff to maintain the network.
3. The district establishes baseline standards for hardware and software across the network to ensure compatibility and performance.
4. The district provides support in layers (for example, local or site level, district level over the network or by phone, and local visits).
  - The district builds a cadre of internal (school and district) experts.
  - The district provides on-site network managers at building level.
  - Students at high school provide “help desk” support to users and get vocational credit.

**Policy and  
Implementation  
Characteristics  
and Practices*****Vision, Leadership,  
and Decision Making***

1. The vision of computer network use is integrated with teaching and learning and includes these components:
  - Universal access to the network by teachers and students
  - Preception of the network as a tool
  - Improvement of instruction

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2. Strong administrative support contributes to the survival of the vision as funding decisions are made.
  3. One person championing the cause helps a network to succeed, but the champion need not be a manager or in position of authority. Important functions include lobbying for support, fundraising, and identifying resources.
  4. Decision makers support the vision.
  5. Decision making is shared between the district and schools. Some decisions are best made centrally at the district level to ensure compatibility among schools. However, schools are best able to determine their individual needs.
  6. Districts maintain the consistency and integrity of the vision and plan. Funding or other opportunities are pursued only if they help the district accomplish its overall educational goals and objectives.

### ***Planning***

1. The plan integrates computer networking with the district's overall strategic plan and with individual school plans. The computer networking plan links a set of achievable, long-term and short-term goals to the vision. It also provides the basis for proposals for funding.
2. The plan provides all schools with a step-by-step guide book documenting how to implement a computer network at the site level and how to gracefully expand and upgrade the network.
3. The plan is multifaceted and includes the following considerations:
  - Addresses educational goals and integration with curriculum
  - Addresses technical support for users, including training on software and hardware
  - Addresses professional development, with incentives to participate
  - Addresses access for students
  - Provides time for teachers to plan instructional use, train on networking, and explore network capabilities
  - Is informed by needs assessment
  - Provides for a sustainable network with adequate budget staffing and provisions for the development,

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maintenance, and trouble-shooting of technical infrastructure

- Addresses selection of infrastructure components based on reliability and performance of network, in addition to cost considerations
- Identifies strategies to communicate the plan
- Defines roles and responsibilities of staff and students
- Involves stakeholders, including parents and community members, in the planning process, so they will understand the impact of computer networks, help define the use of networks for their districts, and agree upon networking goals and objectives
- Involves computer network experts and technology coordinators from schools and the district in the planning process
- Establishes integration of the network with the curriculum
- Links the use of computer networking to district-defined goals for student achievement
- Addresses articulation across grades and across disciplines
- Provides a benchmark through an evaluation plan for measuring the progress and effectiveness of network implementation in relation to student learning

***Operational  
Policies and  
Implementation***

1. Acceptable use policies govern the activities of students and staff on the network.
2. Teachers receive written procedures related to such network issues as use, misuse, technical support, etc.
3. The district provides network access to teachers, students, other school staff, parents, and community members.
4. The district provides network access to students during nonclass hours (lunch, free period, before and after school, etc.).
5. Students are encouraged to use the network outside of school for noneducational purposes.

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## Teaching and Learning Characteristics and Practices

### ***Administrative Uses***

1. Teachers use network capabilities for timely, efficient, and improved communication among students, teachers, parents, administration, and others and to overcome isolation.
2. Teachers use network capabilities for submitting grades, recording attendance, sending correspondence, etc., to increase the efficiency of operations.
3. Teachers use network capabilities to assess student performance, for example, by creating on-line student portfolios.

### ***Instructional Use***

1. Teachers use network capabilities to obtain curricula and lessons, to collaborate, to exchange materials, and to share ideas.
2. Teachers use network capabilities to engage students more directly in all aspects of their learning, for example, creating databases, collaborating, making presentations, and accessing a wide variety of resources.
3. Teachers use network capabilities to involve students in tasks and projects that are meaningful and relevant to the students' lives and world.
4. Teachers use a wide variety of network capabilities and resources to build classroom activities to complement instruction and to address the diversity of interests and learning styles of their students. In such an environment, students help set their own path through the learning process.
5. Through presentations, multimedia, World Wide Web pages, etc., students reach audiences beyond the school boundaries for feedback from the community, business, parents, etc.
6. Students use networks to collaborate on projects.
7. Students use network-based projects to enhance problem-solving skills.
8. Students use networks to explore careers, training, and job opportunities.
9. Students use networks to develop specific job skills.



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***Professional  
Development***

1. The district maintains an ongoing plan for staff development.
2. The district provides professional development to all staff, including teachers, aides, substitutes, and administrators.
3. Professional development is tailored to the individual needs of teachers and staff.
4. District training complements site-based training.
5. Teachers take hands-on courses on how to integrate network resources into the curriculum and instruction.
6. Teachers take hands-on courses on how to use the network infrastructure, network skills, and tools, e.g., the Internet, a Web browser, file transfer, etc.
7. Training can be applied by staff immediately upon returning to their sites.
8. Activities are sensitive to the nonuser perspective.
9. Incentives are provided for participating in training.
10. Network capabilities are used to expand teachers' content knowledge.
11. Sources of training include building-level technology coordinators, colleagues, colleges/universities, students, self-instruction, consultants, conferences/workshops, on-line courses, parents, and community members.
12. Programs encourage staff to obtain personal computers at home.
  - The district allows loans of personal computers for staff development at home.
  - The district arranges low-cost financing and educational pricing.

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